Calcium Carbonate Nucleation Rates Manipulated by Organic Templates as Indicators of Coral's Sensitivity to Ocean Acidification

MARTA WOLFSHORNDL[1]*, DANIEL ANDERSON[1], AND ALEX GAGNON [1]

[1]School of Oceanography, University of Washington, Seattle, Washington, USA (*correspondence: martaw@uw.edu)

Coral reefs provide important ecological and economic functions, but their health is under threat from changing oceanic conditions. Ocean acidification is one such change that is reducing both seawater pH and the thermodynamic driving force for $CaCO_3$-based biomineralization. It is known that coral skeletal growth rates decrease with acidification, but the detailed mechanisms driving this response are still poorly understood. The first step in skeletal growth is the formation of crystal nuclei that act as a template for the rest of skeletal growth. The abundance and location of these nuclei are thought to influence the pace, pattern, and strength of the coral skeleton, and by extension, the development of the very framework that holds reefs together. Classical nucleation theory (CNT) posits that the rate of this nucleation step is governed by two competing factors: the local thermodynamic driving force for mineral growth (oversaturation) and interfacial energy. Based on this framework, CNT predicts that nucleation should be even more sensitive to ocean acidification than overall skeletal growth is. However, we know of no direct measurements for nucleation rates in living coral. CNT also predicts that coral could manipulate nucleation rates through organic-mineral interactions that control interfacial energy, a potential mode for corals to change nucleation rates and adapt to more acidic conditions.

We quantified nucleation rates under changing conditions to understand fundamentally how nucleation works in corals. Inorganic experiments using a perfusion flow cell allowed controlled conditions under which calcite nuclei formed on glass slides under different carbonate chemistry conditions. Parallel experiments were run in live coral, using an *in vivo* nucleation rate assay, to determine how biology responds to the effects of ocean acidification on nucleation formation. Additional ocean acidification inorganic experiments were performed using glass slides with organic functionality to mimic the protein templates corals use in their biological organic matrix. These experiments quantify the effects of changing environmental factors on a crucial step of skeletal growth in coral: nucleation.